

IT'S NOT JUST THE PEDAGOGY: CHALLENGES IN SCALING MOBILE LEARNING APPLICATIONS INTO INSTITUTION-WIDE LEARNING TECHNOLOGIES

Peter Bird and Mark Stubbs
*Manchester Metropolitan University
All Saints, Manchester UK, M15 6BH*

ABSTRACT

Whilst m-learning pedagogy has received considerable attention (e.g. Sharples et. al. 2007, Kukulska-Hulme, 2012), the process of adopting this potentially disruptive innovation within universities has been neglected. Based on a PhD thesis (Bird, 2014), this paper presents some of the findings from a longitudinal study which examined the adoption of m-learning projects in five UK higher education institutions in the period 2008 to 2011. Many m-learning projects have been started as pilots often as a result of external research funding. Using Actor-Network Theory to model embedding trajectories, this paper looks at how the outputs of these projects are encapsulated into wider institutional IT strategy to become institutionally embedded learning technologies.

KEYWORDS

M-Learning, Embedding Actor-Network Theory

1. INTRODUCTION

This research has treated m-learning as an innovation and considered a number of appropriate theoretical approaches including Rogers' innovation diffusion framework (Rogers, 1962), Actor-Network Theory (Latour, 2005), Activity Theory (Engeström, 1987), Structuration Theory (Giddens, 1984), Disruptive Innovation (Christensen, 1997) and the Technology Acceptance Model (Venkatesh and Davis, 2000). Actor-Network Theory (ANT) was chosen as the most promising theoretical lens for an in-depth investigation of m-learning embedding, and a participative fieldwork approach was developed using the Law and Callon's ANT notion of 'points of passage' between local and global networks (Law and Callon, 1991) to illuminate factors that affect embedding. Examples of two institutional m-learning embedding trajectories taken from a three-year, longitudinal case study involving five universities using smartphone applications to assess students in medical practice, show a contrast in outcomes between institutions which have encapsulated project results in IT strategy and those which have lacked a process to achieve this. Several institutional issues are identified that help or hinder embedding, such as fragmentation of IT strategy and decision-making, and the need to provide students with access to multiple institutional services on their mobiles. The role of people and artefacts in forming a link, or 'point of passage', between m-learning projects ('local networks') and institutional IT strategies and services ('global networks') was found to be key to understanding processes of embedding.

2. M-LEARNING AND EMBEDDING

Although mobile learning researchers use the term embedding, they are mostly focusing on the learning method or model and how that can be maintained in the learning environment (e.g. Attewell, 2005, Kukulska-Hulme, 2012) asking the question is the pedagogy effective and can it blend with other learning methods? However, Traxler (2005) has discussed issues of mobile learning and institutional strategies and processes and gave pointers to potential problems such as impacts on teaching and work-life balance. He

also pointed to issues around the technology in that it was unfamiliar to IT support staff and has different infrastructure issues than with PCs, in that mobile devices have a shorter useful life and cannot be installed in fixed areas (Kukulska-Hulme and Traxler, 2005). Traxler also discusses the challenge that m-learning brings to a university IT provision model which has been designed as a 'benign industrialisation and electrification of learning' (Traxler, 2010, p. 156) in order to deliver mass learning. M-learning is seen here as a potential shift in control from the institution towards the learner, requiring new ways of managing IT provision. A recent study of European mobile learning projects also acknowledges the apparent lack of strategy for handling this situation, asking 'to what extent are e-learning policy and initiatives taking account of research project results and the potential of mobile learning?' (Kukulska-Hulme et al., 2011, p. 152). However only Traxler (2005, 2009, 2010) has consistently referred to how such learning interacts with the university business model and especially its model of IT provision.

3. ACTOR NETWORK THEORY AND THE LAW/CALLON PROJECT TRAJECTORY

Actor-Network Theory (ANT) states that agency resides both in people and objects such as innovations insisting that all entities, both human and non-human, be subjected to the same process of social analysis (Law, 1994). ANT identifies the set of processes involved in projects of social ordering as networks and looks at the changes that take place in those networks through a project. ANT also has the concept of translation where the people, objects and processes have specific needs that then get translated into more general and unified needs which are all met by one solution. It also has the concept of irreversibility where a network is established and can resist competing translations to become irreversible. Actor-Network Theory provides a useful model for looking at m-learning as the various actors (the university, teachers, students, IT services, the innovation itself etc.) go through a process of translation to find a stable way of working together.

Actor-Network Theory has gained popularity as an IS research approach, particularly in looking at situations where technology is an agent of change (e.g. McMaster et al., 1999, Walsham and Sahay, 1999). Activity Theory (Engeström, 1997) has been widely applied to m-learning (e.g. Sharples et al., 2007). As a theory it is well positioned to look at learning solutions but is it a good choice to model institutional embedding? Spinuzzi's (Spinuzzi, 2008) study of developing knowledge networks in US telecommunications organizations uses both ANT and Activity Theory to look at how a telecommunication service provider operates. He concludes that Activity Theory is better suited to looking at networks of learning and learning activities but that it had weaknesses in looking at links between networks, 'the boundary objects' (Spinuzzi, 2008, p. 206). As this research had a goal of looking at how m-learning projects became linked to overall university strategy then links or boundary objects were a key focus and hence ANT as opposed to Activity Theory was chosen.

Looking at project failure in the aircraft manufacturing industry, Law and Callon proposed the concept of local and global networks and the boundaries between the two (Law and Callon, 1992). They identified three factors which influenced the success or failure of a project with the most significant being 'the capacity of the project to build and maintain a global network which will for a time provide resources of various kinds in the expectation of an ultimate return' (Law and Callon, 1992, p. 46). They also talk about points of passage between the two networks and the effectiveness of points of passage could be a key issue in the embedding of m-learning. Significant factors will be the ability of the local network to build links with the global network and influence the global network to approve and support the innovation and develop institutional policies to support it. Actors, be they individuals or even artefacts, need to become points of passage between the two networks for that influence and support to be achieved. In addition, a further strength of this local/global network model is the temporal aspect in that it looks at project trajectories to focus on a project over time rather than the identification of a specific moment of translation.

4. TWO INSTITUTIONAL PROJECT TRAJECTORIES

The two institutions (A and C) described below were part of a five-university consortium looking at assessment of health students when they were out in clinical practice. The project had many strands but a significant feature was the development of an assessment application which ran on a smartphone and uploaded results back to the students' institution. Despite many issues, the project successfully proved the concept and the device was used by students but was hampered by external funding requiring all devices (>1000) to be purchased in one transaction. The consequences were that the devices gradually became less attractive to students as smartphones such as the iPhone reached the market.

The researcher had access to the project from 2008 until 2011, observing program-level meetings (which involved representation from all five universities) and interviewing key staff within each institution. Staff broadly come into four categories Executive and Management (such as Deputy Vice-Chancellors or Faculty Deans), site leads (running the project for that institution), tutors using the technology with students and IT staff at various levels who were either faculty/project based or central institutionally based. Over forty interviews were conducted and that information was triangulated with meeting observations and access to numerous project documents.

Law and Callon developed a model which represented in diagrammatic form, the 'translation trajectory' (Law and Callon, 1992, p. 47) of a project. The relative position of a project in the trajectory is a combination of the strengths of the two main factors – capacity to build and maintain a global network and the ability to build a local network. If both factors are high then the project is likely to succeed and establish itself as a point of passage and thus become an embedded solution. The next diagram (Figure 1) is a graphical representation of their model (Law and Callon, 1992, p. 49). Note that a projects position on the graph is based on a relative judgment derived from interview and observation data i.e. no scale or measurement is involved.

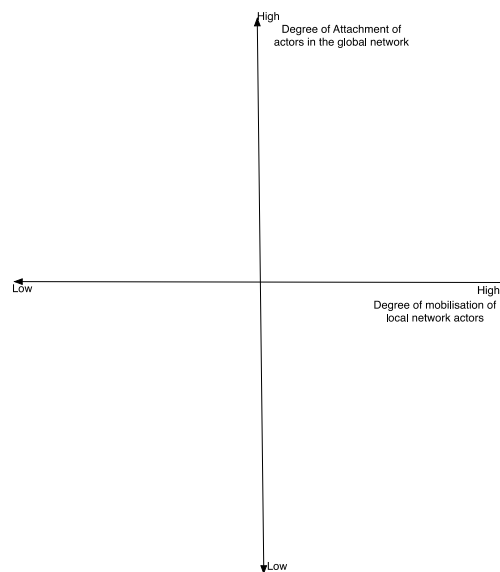


Figure 1. Law and Callon's graphical representation of global/local strength

The next sections apply this model to the two institutions (A and C).

4.1 University A

University A was the lead partner in a five university collaborative project which was trialling a mobile assessment tool. The IT structure within the institution was distributed in that it had elements of being centralised: the network, the VLE, email etc., were provided centrally, but faculties had differing levels of autonomy in how they ran their own IT. Faculty IT managers reported into the Deans or Heads of

Department although they also had connections with central IT services. Some faculties ran their own servers giving them considerable autonomy in their decision making, whereas others bought in server support from the central IT department.

4.1.1 University A Mobile Strategy

Prior to the project starting, there was no real mobile strategy in evidence apart from the use of BlackBerry devices by staff in senior and executive roles, and it is unclear how far that situation had moved during the project lifetime. The project clearly felt that it needed to break new ground and its support from central IT services was only in helping with issues such as authentication of devices. Expertise on m-learning came primarily from the sub-contractors who developed the mobile application and the rest was developed by trial and error over the project where the team became skilled in finding solutions to a whole range of technical and administrative issues. The priorities of the institution were supporting student laptops and introducing a new VLE and quite reasonably m-learning was seen as a niche:

“ There’s a certain wariness and reluctance to go into the mobile learning world or just the world of mobile devices at all” *Faculty IT support*

“It feels to me like mobile technology in terms of enterprise adaptation is where PCs were twenty years ago with people thinking, PCs they are toys, they’re personal things, and then corporate IT departments spent the next ten years trying to bring them under control ” *Faculty IT Manager*.

Lack of the ability to integrate with other systems was also cited as a major disappointment within the project. It is clear from all five institutions that just having an assessment tool on a mobile will not engage the students fully as it is a once-a-term experience: systems are required which create multiple modes of usage and thus regular interaction. The absence of the ability to access the VLE from the mobile devices was a big disappointment to many tutors and local IT staff:

“The VLE which was bought by the university but it doesn’t have a mobile interface and I think they acknowledge that they missed a trick by not including it in the VLE ITT document” *Deputy Site Lead*

4.1.2 Points of Passage

In Actor-Network terms, there is clear local network that can exist mostly independently of the global network. It needs occasional support from the institution in areas such as procurement but in terms of resources and expertise is largely independent. There appeared to be no mechanism to capture the experiences of the project in a way that would inform a longer-term mobile strategy, no visible capacity-building link that captures the local network experience into the global network IT strategy:

“Well we were sad when they came up with an IT strategy and when we read it our Project did not figure into it at all and wouldn’t you have thought they’ve got a very big project which is gaining experience?” *Deputy Site Lead*

And when interviewed, representatives from central services conveyed the fact they felt the project was not mainstream:

“I’ve had discussions about the project purely in the context of we’re looking at some sort of handheld device and to understand what the project is and see if there are any synergies with that, so its really peripheral to us.” *IT User Services Manager*

4.1.3 Embedding

The evidence would suggest that embedding at an institutional level was weakened perhaps because there wasn’t a clear and strong point of passage between the project and the overall institution global network. In effect the faculty had the IT staff and resources (provided through the project) to continue without much support from any central function. Even though the central function is at risk of losing some of the project’s

work within the longer-term strategy, the local network could maintain the project work as long as it could finance it. And indeed this is what transpired as one part of the project (Medicine) was able to get a grant (from healthcare funding sources) to equip medical students with iPhones and continue the online assessment software for those students. In addition a number of other resources (apps) were to be placed on the iPhone to give the students access to electronic versions of drug and anatomical information. Having learnt the lessons from having to support out-of-date devices and perhaps more importantly, providing students with multiple reasons to use the device, they embarked on a process where all medical students will have the devices. But despite this effort, the link to the overall institution strategy is still somewhat tenuous –the iPhone work can progress without support from central IT services.

There was a persistent concern that the lessons of the project could be potentially lost or could be duplicated in different faculties:

“Early on in the project, agreements may have been put in place with someone in central IT services and that person then moves on and so you find that a year later you are suddenly having to explain it all again to somebody new” *Project Manager Mobile*

“And I think the danger is that you will end up with people doing things with mobile technology in an uncontrolled, maybe slightly inefficient way and if you had some sort of central policies in place and services in place you could actually make better implementations. But, that’s the way it is” *Faculty IT Manager*.

This last quote predicts what Latour (2005) referred to as competing translations, several solutions to a similar problem existing in parallel leading to duplication of effort.

4.1.4 ANT Analysis- University A

The project trajectory is represented by the following diagram (Figure 2):

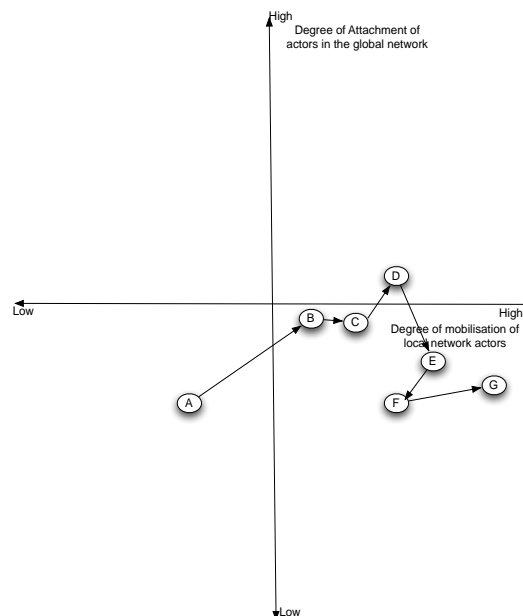


Figure 2. Project Trajectory University A

At point A, the project commenced with little involvement from the global network. At point B, technology choice, the local network asked the global network in the form of IT Services but centrally there was little knowledge to help. Pilots took place in all five institutions (point C) and choices over technology were made. At point D (procurement), the global network offered considerable help in procuring devices and negotiating agreements with suppliers. Implementation (E) and Final Project service (F) occurred as the local network tried to get students to engage with the devices, Some interaction with the global network occurred as presentations were made to IT Services representatives but no formal mechanism to share the project

results was established. Embedding did not occur in most subjects apart from Medicine due to funding shortages and the poor student experience with the system. Embedding (at least in the area of Medicine) occurred because the mobilisation and independent capability of the local network was strong and did not require much if any support from the global network. The degree of attachment of global network remained weak reflecting the fact that capacity-building links between the project and future strategy did not appear strong and the concept of m-learning is very much seen as a niche rather than a core service.

4.2 University C

University C was a long established medium-sized university with a strong reputation for technology and innovation. The institutional IT structure was centralised with some faculties having their own local support team but the majority of services provided centrally. Central IT Services were closely involved with the project and provided the institution's IT representative to the joint IT steering group which the five institutions set up to oversee the device selection and application development process. In addition to supporting the work of the project within University C, IT Services also supplied a help-desk which was first-line support for all the students with mobile devices issued through the project, across the five universities. This was a service that the other four institutions made a financial contribution to and a good example of the capacity-building strategy that characterised University C's approach to the project.

4.2.1 University C Mobile Strategy

Consistent with other institutions, no m-learning strategy existed at the start of the project and Central IT Services saw the project as an opportunity to learn about m-learning and the problems involved. The same team already ran more than 300 corporate mobile devices used by executives, managers and senior academics and supported a facility to send text messages to students. IT Services were concerned about the proliferation of mobile solutions and applications so wanted to create a position for someone who would oversee the implementation and try to bring some order to the situation:

"The post was the role of mobile technology advisor for we had various corporate users, a variety of mobiles, there wasn't any centralised support and people were starting to do things for teaching and learning so the job itself was an open remit, just support this E strategy vision of a wireless enabled campus" *User Services Manager, IT*.

In this university it is interesting to note that the team were driven by both business needs and learning and teaching needs and the same team oversaw all mobile-related technology within the institution. In many institutions, these two aspects are often divided with m-learning seen as part of learning technologies and corporate phones usually associated with the telephony support team. And University C also felt that with corporate smartphones increasing there was synergy with m-learning applications:

"People were constantly complaining about new phones, so really the role of the job was to try and smooth the introduction of smartphones and put in place better business applications and systems" *Mobile Technology Advisor*.

The department also placed mobile as part of its customer support services rather than as part of its technology group:

"And most people would have put mobile technology in with the techie lot. And I was quite keen that it didn't go in with technology because I think the problem was with the customer facing issues" *User Services Manager, IT*.

IT Services saw that m-learning was something they would eventually have to support and viewed the project as a great opportunity to learn about the technology and its associated issues and build future capacity.

4.2.2 Points of Passage

In terms of IT Strategy, there was a clear point of passage between the project and the institution. The individual who provided mobile technology support to the project also provided it for the institution and reported to a manager who had a seat on the IT strategy board. So expertise flowed from IT services into the faculties that were trialling the project software and results were fed back giving the opportunity to influence the institution IT strategy. An example of the benefits of this approach is that University C was amongst the first UK institutions to implement CampusM, a student portal accessible via smartphones. The same

individual was also a prominent member of the five institution IT steering group and also managed the first-line helpdesk system, which was provided to all the five partner institutions. The IT department thought advantages had arisen from hosting the help desk for the five institutions:

“And it definitely has worked out. By hosting it I think we got a much better understanding about it all when it’s together, device and learning application.” *User Services Manager IT.*

University C’s site lead saw their objective was to disseminate the m-learning experience into other faculties:

“The objective was taking mobile learning across the institution, which I haven’t had that much success with, largely because of the problems with the project technology” *Site Lead.*

Thus the impact of the mobile assessment application on other departments per se was minimal. However the site lead also had a seat on the teaching and learning committee for the university so rather than abandon any push because of the project difficulties, they looked for other opportunities:

“What I did was I looked at what we were doing that was successful with mobile technology that the rest of the University could do. We did lots of work around audio reflection, student self-assessment and audio feedback which has been distributed across the university” *Site Lead.*

This shows that there is a point of passage into the overall university teaching and learning strategy and where projects have successes there is an opportunity to spread and embed new practice, complementing the point of passage that exists in the IT department.

4.2.3 Embedding

Embedding did not occur in terms of the mobile assessment application due to device limitations. However, there was evidence to suggest that the project had a lasting influence on the institution, notably in the use of audio feedback, the CampusM student portal, a blog site for mobile aimed at students and also some positive experience with the project devices that helped reinforce the benefit of using mobiles for both IT and academic staff:

“We need to start implementing it for teaching and learning here. The main benefit is just seeing how all the systems, the architecture and stuff tie in together so that we can then decide what works and what doesn’t” *Mobile Technology Advisor*

Despite the lack of embedding of the mobile assessment tool, evidence of a stronger mobile computing strategy following the project is apparent with perhaps the greatest range of mobile access to university systems amongst the five project partner institutions. The presence of an influential point of passage in terms of the mobile technology advisor has brought this about, marrying the project experience with wider institutional needs.

4.2.4 ANT Analysis University C

This is represented by the following diagram (Figure 3):

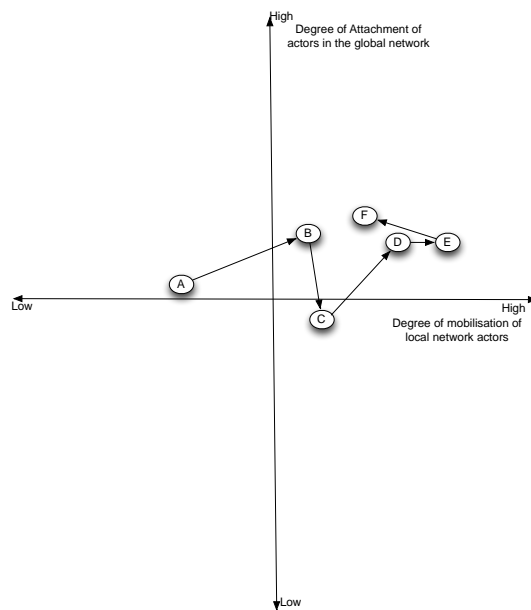


Figure 3. Law/Callon Trajectory University C

When the project started (A), both the global and local networks had a high degree of attachment to the project, the global network seeing it as an opportunity to develop mobile technology strategy for the institution. The pilot service (B) was successful, the global network offered support by developing a simple assessment application on which students gave positive feedback. At point C (technology choice) both the local and global networks were disappointed that the software technology choice was incompatible with the institutional E-portfolio but nevertheless accepted the decision and prepared to deploy the project devices to students. Indeed the global network offered to provide a project-wide helpdesk for the five institutions, seeing this as a further opportunity to learn from the project. The initial attempts to use the devices were largely unsuccessful as many students saw the installation process as too complex. Through phase E, devices were re-called and re-launched to students with pre-installed software but by then, students were unwilling to engage with the devices, not helped by the growing obsolescence of the technology. When it came to stage F, embedding, the Health subjects did not see it as viable to continue with the existing application and there was no budget to procure new devices for students. The local network's enthusiasm for mobile technology was placed on-hold but the global network used the project experience to increase mobile access to institutional systems, a strategy that continues.

5. EMBEDDING ISSUES IN M-LEARNING

The key m-learning issues that have arisen from the field research are:

The business model. At the time of the research, it appeared that mobile service providers and Education had not produced a business model which will support students. If m-learning is mandated for assessment purposes, or is a necessary aid to field research tasks, then no model existed to support this. The institution is not able to demand that students all have smartphones with certain minimum capabilities and cannot assume that data charges will be bundled into the students' contract arrangements. Perhaps the institution could cover some of these student data costs (where it forms part of a mandatory assessment), but the mobile service providers do not have a billing system that can cope with this. The students could perhaps claim a contribution back from the institution, but expense systems would most likely creak under the weight of large numbers of small claims. Recently there may be signs that industry is starting to respond to some of these needs with the provision of data-only contracts with tablets such as the iPad and that could alleviate some of the problems experienced.

The mobile industry has not tended to value long-term customer loyalty in its business model, with customers frequently having to threaten contract termination to get a competitive deal (Ofcom, 2012). This issue of education-friendly charging plans needs to be tackled probably at least at the sector level so that affordable and flexible models can be offered, rather like the bulk discounted software licensing deals that are offered into the education sector. Network operators would have to sacrifice some shorter-term profitability in return for the opportunity to increase product loyalty and revenues in the longer term (Venkatesh et al., 2012), a model which seems to have influenced companies such as Microsoft and Google to develop education-friendly email and cloud storage offers, (e.g. Office 365 and Google Apps for Education).

Multiple Service Offerings. All institutions that were investigated highlighted the need to provide a mobile environment that students can engage with in a number of ways. Access to other services such as student portals, VLEs and university email accounts were all features that both students and tutors felt should be present. Most institutions did not produce a strategy or policy which stated what students could expect to be able to access from their phone handsets, i.e. what a minimum level of service would be. It was also not clear if institutions were considering mobile access when they procured new IT systems.

The Disruptive Nature of Mobile computing. Even before this research commenced, it was clear that many in an Education setting view mobile devices suspiciously (Sharples, 2002). Students have brought laptops into lectures for many years but tutors will be more suspicious to see students using handheld devices. Handheld devices are often regarded as something used for personal and social activities whereas laptops may be seen as business or education tools. Yet either laptops or mobile devices are equally capable of entering both worlds. With the five-institution mobile assessment project, the challenges of taking a handheld device into the healthcare world are only too apparent. Not only do the healthcare providers view the devices suspiciously and see them as an added security risk but also the service users will react to them in different ways. Future strategies are likely to be based on using students' own devices, and that was the majority view from the field research, then institutions would not be able to control the features of the device. Hence students would have to be accepted in healthcare with devices that could take pictures, make movies and record sound. Institutions saw applications for mobile assessment technology in teacher education but education providers are already engaged in a struggle with students using their devices in inappropriate ways (Cook et al., 2011).

Fragmented IT Strategy. In 2010/2011 there was evidence that some IT departments viewed m-learning and mobile technology as non-core. Subsequently there has been a significant uptake of smartphone and 3G technology by the general population (Ofcom, 2012) fuelled in particular by social networking applications such as Facebook and Twitter. Growth in HE students' ownership of smartphones has been exponential (Dixit et al., 2011) and perhaps now almost ubiquitous with many institutions responding by offering some form of mobile access to systems and enhancing Wi-Fi coverage to cope with much greater access on campus by students through various forms of mobile devices. Despite a much more open and strategic view of m-learning, the fragmented structure of some HE IT departments remains a barrier to overcome, an ever stronger reason to create effective points of passage that can enable joined-up thinking. The evidence from the five institutions examined in this research shows that IT functions are often sub-divided across the institution by functions. Any new technology that is introduced faces the challenge of this functional split but arguably m-learning is the most challenging as it can touch all areas. Adding to this functional distribution complexity, there is also the additional challenge within some institutions where IT provision is neither centralized or distributed creating a random hybrid structure where some faculties retain much greater IT independence based on historically strong 'local' networks. The distribution and organization of IT Services is a barrier to transfer of knowledge that will not be easily overcome. Innovation theories also tell us that independence of departments and faculties acts as a barrier to embedding, as it prevents a coordinated strategy being developed (Christensen and Eyring, 2011). 'Fragmented responsibility' is a major barrier that must be overcome to achieve a consistent student experience in a world where faculties and departments can develop their own mobile applications or Web 2.0 services.

6. SUMMARY

This paper has presented a number of issues that were experienced with larger-scale m-learning projects, notably the issue of how to support student-owned devices financially, provide integrated access to university systems and handle the ethical challenges of students using devices in sensitive areas such as hospitals and schools. However the major focus of the work was embedding and the Law/Callon model puts a sharp focus on the problems of developing coordinated m-learning strategy when institutions fragment their IT responsibilities. The Law/Callon model described above has been extended to give a third dimension that places the fragmented nature of IT strategy in sharp focus (Bird, 2014). This model has applications in any institutional IS scenario and the authors now plan to apply it to a whole institution curriculum change project which was underpinned by major restructuring of corporate and learning technology systems.

The field research was carried out prior to 2011 and thus it would be interesting to see this repeated in today's context where institutions have clearly recognised the significance of mobile access to their systems. At the end of 2014, we can reliably say that smartphones are now ubiquitous within the UK HE landscape. Recent data from Manchester Metropolitan University shows over 31,000 active users with VLE and timetable access the most popular applications. Both University A and C could report similar experiences and a recent CampusM user group meeting demonstrates widespread adoption (see www.youtube.com/watch?v=sSBX-ch4eDM). However it remains unclear whether institutions have longer-term strategies to develop mobile access and whether their fragmented IT structure can learn from future localised experiments with new mobile technologies and applications.

REFERENCES

- ATTEWELL, J. (2005) From Research and Development to Mobile Learning: Tools for Education and Training Providers and their Learners. *mLearn 2005*. Cape Town.
- BIRD, P. (2014) Potentially Disruptive IS Innovation in UK Higher Education Institutions: An Actor-Network Theory Analysis of the Embedding of M-learning, PhD. Thesis, Manchester Metropolitan University
- CHRISTENSEN, C. & EYRING, H. (2011) *The innovative university: Changing the DNA of higher education from the inside out*, New York: Jossey Bass
- CHRISTENSEN, C. M. (1997) *The innovator's dilemma : when new technologies cause great firms to fail*, Boston, Mass.: Harvard Business School Press.
- COOK, J., PACHLER, N. & BACHMAIR, B. (2011) Ubiquitous mobility with mobile phones: a cultural ecology for mobile learning. *E-Learning and Digital Media*, 8 (3), pp. 181-196.
- DIXIT, S., OJANPERA, T., NEE, R. & PRASAD, R. (2011) Introduction to Globalization of Mobile and Wireless Communications: Today and in 2020. In DIXIT, S., OJANPERA, T., NEE, R. & PRASAD, R. (Eds.) *Globalization of Mobile and Wireless Communications*. Amsterdam: Springer Science and Business Media.
- ENGSTRÖM, Y. (1987) *Learning by expanding : an activity-theoretical approach to developmental research*, Helsinki: Orienta-Konsultit oy Helsinki.
- GIDDENS, A. (1984) *The constitution of society: Outline of the theory of structuration*, Univ of California Press.
- KUKULSKA-HULME, A. & TRAXLER, J. (2005) *Mobile learning : a handbook for educators and trainers*, London, Routledge.
- KUKULSKA-HULME, A. (2012) How should the higher education workforce adapt to advancements in technology for teaching and learning? *Internet and Higher Education*, 15 (4), pp. 247-254
- KUKULSKA-HULME, A., SHARPLES, M., MILRAD, M., ARNEDILLO-SANCHEZ, I. & VAVOULA, G. (2011) The genesis and development of mobile learning in Europe. IN PARSONS, D. (Ed.) *Combining E-Learning and M-Learning: New Applications of Blended Educational Resources*. Hershey, PA: Information Science Reference, pp. 151-176
- LATOUR, B. (2005) *Reassembling the Social: An Introduction to Actor-Network-Theory*, Oxford: Oxford University Press.
- LAW, J. (1994) *Organizing Modernity*, Cambridge: Blackwell.
- LAW, J. & CALLON, M. (1992) The Life and Death of an Aircraft: A Network Analysis of Technical Change. In BIJKER, W. E. & LAW, J. (Eds.) *Shaping Technology/Building Society Studies in Sociotechnical Change*. Cambridge Massachusetts: The MIT Press, pp. 21-52.

- MCMMASTER, T., VIDGEN, R. T. & WASTELL, D. G. (1999) Networks of association and due process in IS development. *Information Systems: current issues and future changes*, pp. 341-357.
- OFCOM (2012) *The Communications Market 2012*. [online] [accessed 8th July 2013], <http://www.stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports>
- ROGERS, E. (1962) *The Diffusion of Innovations*, New York: The Free Press.
- SHARPLES, M. (2002) Disruptive devices: mobile technology for conversational learning. *International Journal of Continuing Engineering Education and Life Long Learning*, 12 (5-6), pp. 504-520.
- SHARPLES, M., TAYLOR, J. & VAVOULA, G. (2007) A theory of learning for the mobile age. In ANDREWS, R. & HAYTHORNTHWAITE, C. (Eds.) *The SAGE handbook of e-learning research*. London: Sage Publications.
- SPINUZZI, C. (2008) *Network: Theorizing knowledge work in telecommunications*, New York: Cambridge University Press.
- TRAXLER, J. (2007) Defining, Discussing and Evaluating Mobile Learning: The moving finger writes and having writ *The International Review of Research in Open and Distance Learning*, 8 (2),
- TRAXLER, J. (2009) Current State of Mobile Learning. In. ALLY, M. (Ed.) *Mobile Learning: Transforming the Delivery of Education and Training*, Athabasca: Athabasca University Press, pp. 9-24
- TRAXLER, J. (2010) Students and mobile devices. *Research in Learning Technology*, 18 (2), pp. 149-160.
- VENKATESH, V. & DAVIS, F. D. (2000) A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management science*, 46 (2), pp. 186-204.
- VENKATESH, V., THONG, J. & XU, X. (2012) Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. *MIS Quarterly*, 36 (1), pp. 157-178.
- WALSHAM, G. & SAHAY, S. (1999) GIS for district-level administration in India: problems and opportunities. *MIS Quarterly*, 23 (1), pp. 39-65.